

Sustainable TU Delft

Climate university in a resilient region

Andy van den Dobbelsteen & Deirdre van Gameren

TU Delft Sustainability Coordination

1

Energy Slaves

Winner of a Gouden Reiger
(Dutch Oscar for commissioned films)

Made for the
Zero-Energy Design
MOOC and ProfEd

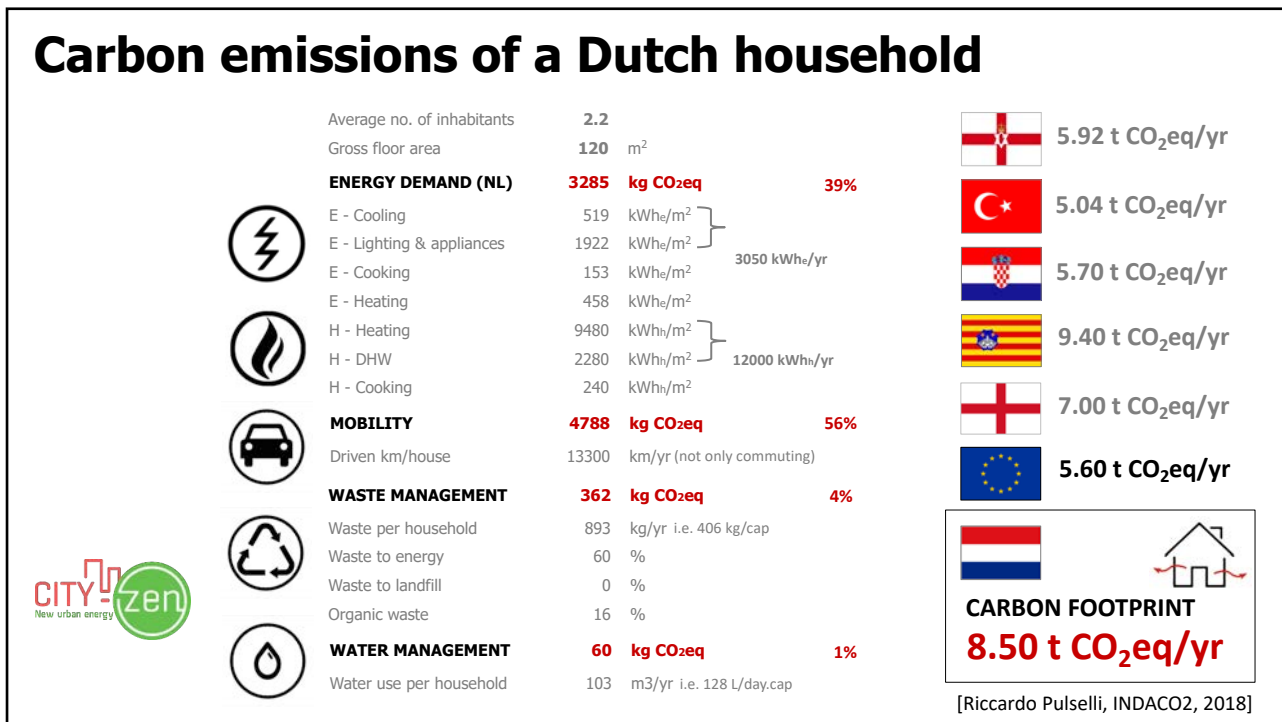
Winner of the 2020 EdX Prize
(the world's best online course)

[View on youtube](#)



2

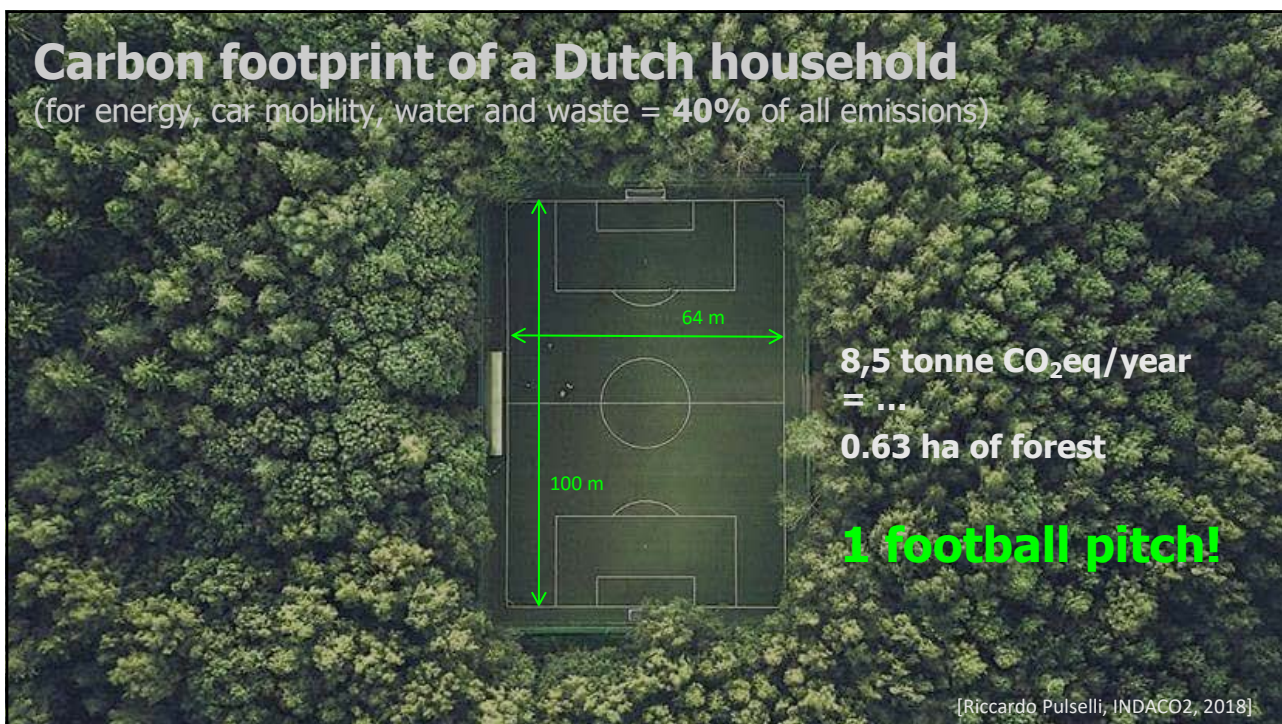
Carbon emissions of a Dutch household



3

Carbon footprint of a Dutch household

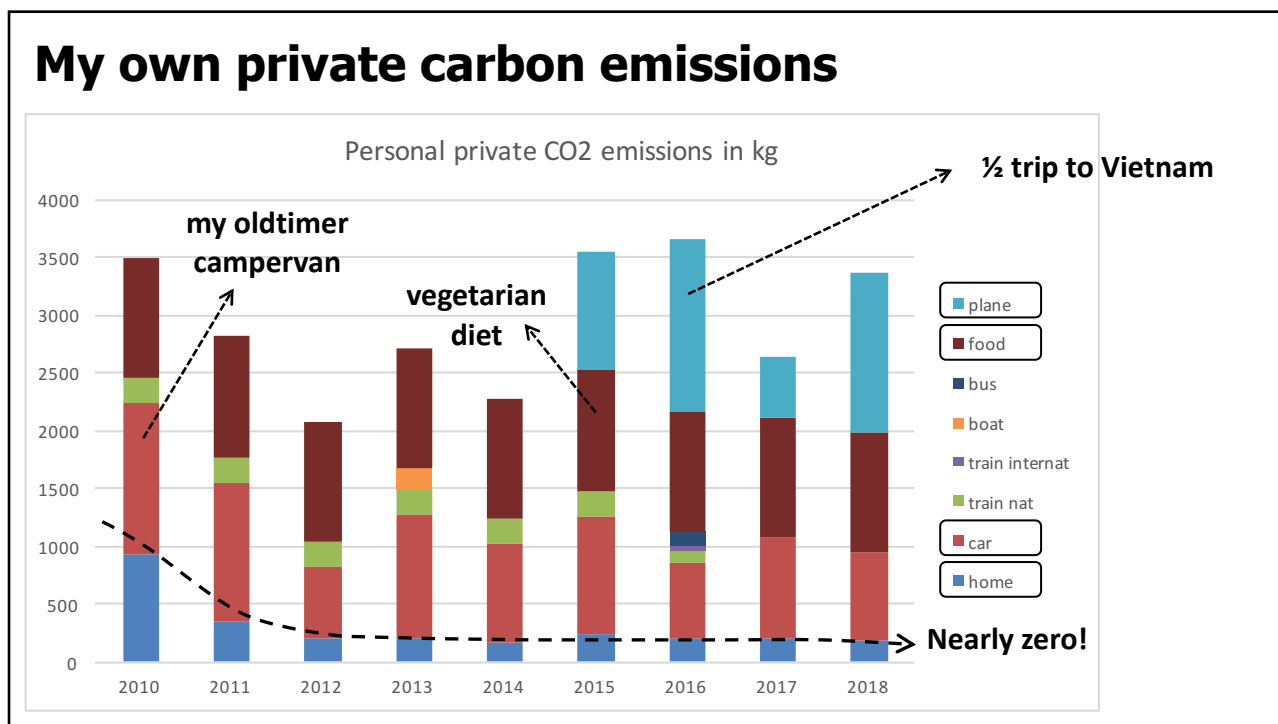
(for energy, car mobility, water and waste = 40% of all emissions)



4

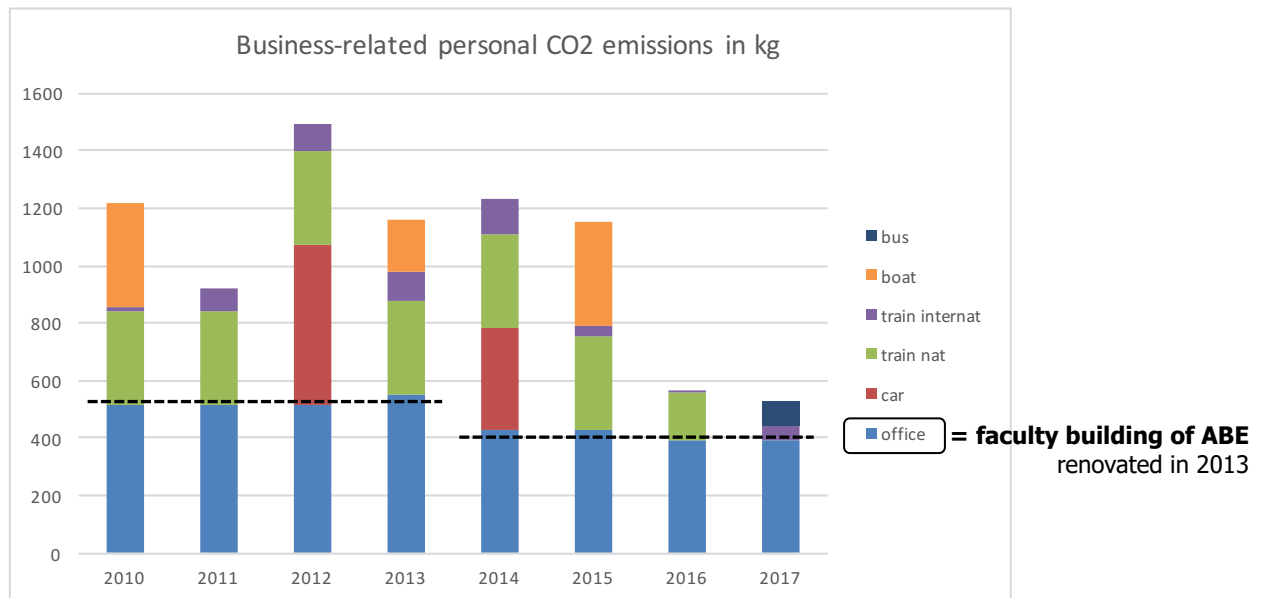
		START	METER STANDINGS																	
			01/01/20	01/01/21	01/01/22	01/01/23	01/01/24	01/01/25	01/01/26	01/01/27	01/01/28	01/01/29	01/01/30	01/01/31	01/01/32	01/01/33	01/01/34	01/01/35		
days since last measurement		0	369	744	57	187	213	63	1	215	141	216	155	209	193	335	92	21	145	170
Measuring is knowing...																				
electricity																				
1 - low tariff	kWh	20901	2762	1600	350	1156	1299	477		1680	857	1061	883	1015	0	1661	470	37	772	789
2 - high tariff	kWh	19477	2922	1624	286	1138	1125	417		1592	827	1034	900	980	0	1688	482	53	704	819
5 - fed in	kWh	0	0	1	3	5	18	1		46	6	35	8	41	0	30	18	7	11	42
total	kWh	40378	5684	3223	633	2289	2406	893		3226	1678	2060	1775	1954	0	3319	934	83	1465	1566
heat	GJ	224,53	36,15			37,01	3,29	7,16	59,86	6,85	15,29	2,41	21,75	2,5	12,54	18,66	1,72	0,06	0	75,63
water	m3	614	106				188	17		82	40	60	43	53		164	31	0		108
			CONSUMPTION SINCE LAST MEASUREMENT																	
electricity																				
1 - low tariff	kWh		2732		2365		2269			2066		1961		1903		1810			1809	1764
2 - high tariff	kWh		2890		2287		2091			1925		1903		1885		1839			1753	1755
5 - fed in	kWh		0		5		21			45		42		49		33			51	67
total	kWh		5622		4647		4338			3946		3822		3739		3616			3511	3452
heat	GJ		35,76				21,13		70,77	22,00		18,10		24,32		21,57			0,00	66,02
	MWh		9,93				5,87			6,11		5,03		6,75		5,99				18,34
with heat pump (COP)	MWh	3	3,31				1,96			2,04		1,68		2,25		2,00				6,11
water	m3		105				99			79		102		96		113				92
			CONVERTED TO REAL ANNUAL VALUES																	
electricity																				
1 - low tariff	kWh		2732		2365		2269			2066		1961		1903		1810			1809	1764
2 - high tariff	kWh		2890		2287		2091			1925		1903		1885		1839			1753	1755
5 - fed in	kWh		0		5		21			45		42		49		33			51	67
total	kWh		5622		4647		4338			3946		3822		3739		3616			3511	3452
heat	GJ		35,76				21,13		70,77	22,00		18,10		24,32		21,57			0,00	66,02
	MWh		9,93				5,87			6,11		5,03		6,75		5,99				18,34
with heat pump (COP)	MWh	3	3,31				1,96			2,04		1,68		2,25		2,00				6,11
water	m3		105				99			79		102		96		113				92
TOTAL PERSONAL ENERGY		persons	4	2010	2011	2012	2013	2014	2015	2016	2017	2017/8								
				2,23 MWh	1,99 MWh	1,57 MWh	1,50 MWh	1,37 MWh	1,50 MWh	1,40 MWh	1,38	2,39 MWh								
				100%	-10,9%	-29,5%	-33,0%	-38,5%	-32,9%	-37,2%	-38,3%	7,1%								
Carbon emission																				
own electricity use	kg/MWh	0	589 kg (ref)	0 kg	0 kg	0 kg	0 kg	0 kg	0 kg	0 kg	0	0 kg								
heat pump (source unknown)	kg/MWh	419	347 kg	347 kg	205 kg	213 kg	176 kg	236 kg	209 kg	209 kg	209	640 kg								
TOTAL CARBON EMISSION																				
				936 kg	347 kg	205 kg	213 kg	176 kg	236 kg	209 kg	209	640 kg								
				100%	-62,9%	-78,1%	-77,2%	-81,2%	-74,8%	-77,6%	-77,6%	-31,6%								
average Dutch household		persons	2,2	2010	2011	2012	2013	2014	2015	2016	2017	2017/8								
				3000 kWh	0,419	571 kg	2,3													
				1470 m3 ap	1,89	1263 kg	4,5													
				17,37 MWh	7,90	1834 kg														
				-49,0%	-81,1%	-88,8%	-88,4%	-90,4%	-87,1%	-88,6%	-88,6%	-65,1%								

5



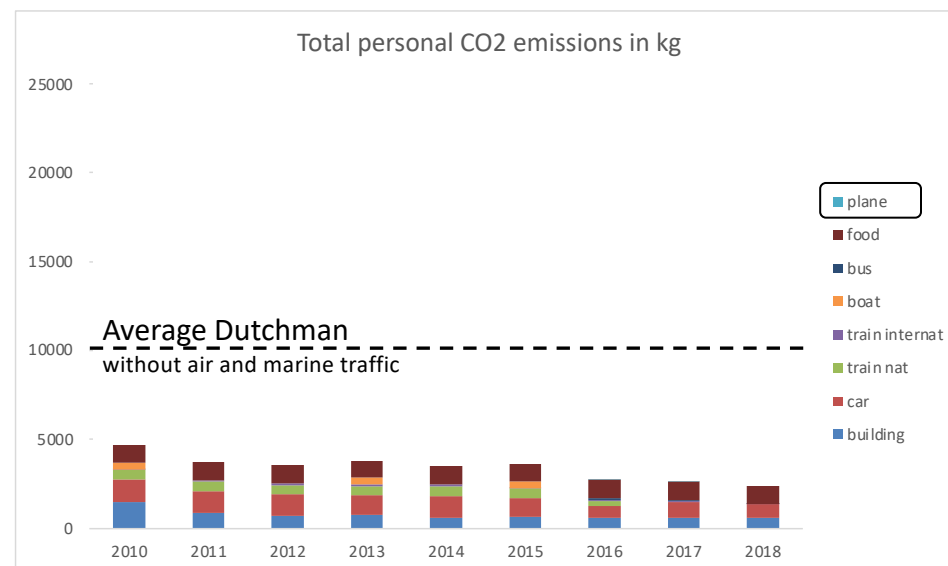
6

My business-related emissions



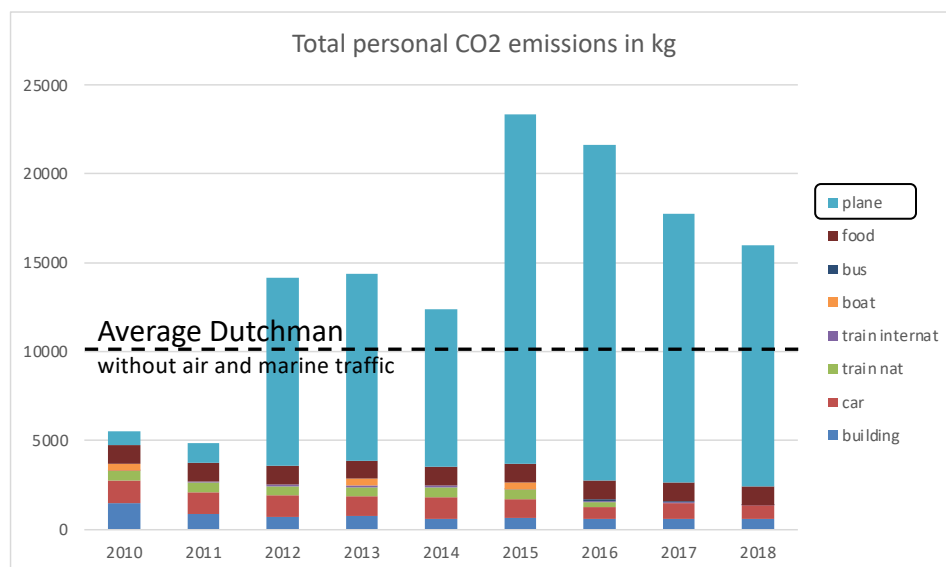
7

My overall performance



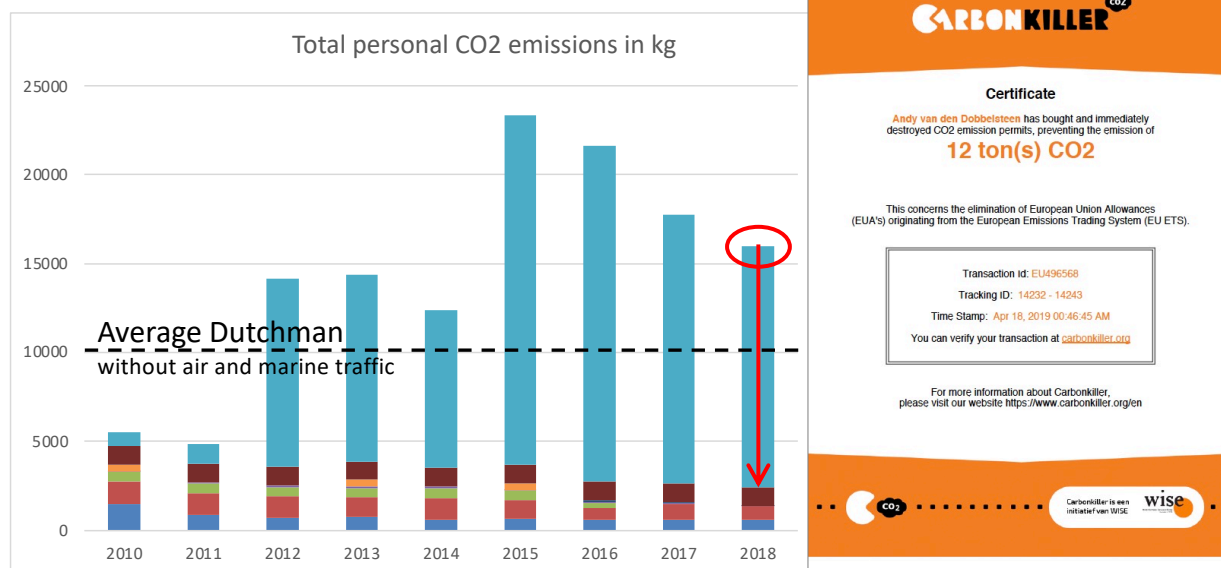
8

My overall performance

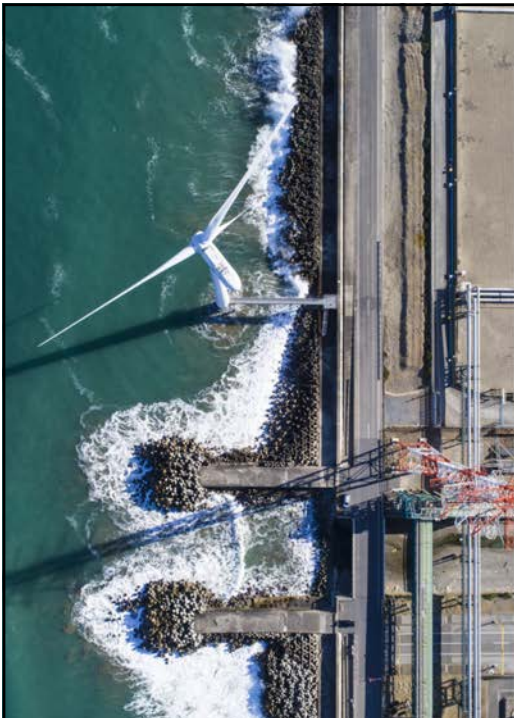


9

My overall performance



10



TU Delft position on Climate Action

The Climate Action mission of TU Delft

There is no doubt that the anthropogenic emissions of greenhouse gases are changing our living environment through their impact on the global climate system. TU Delft will harness its innovative powers to support the world-wide transition to non-fossil energy, and adaptation of the living environment to the consequences of global warming.

11

CLIMATE ACTION PROGRAMME TU DELFT

Led by prof. Herman Russchenberg



12

Climate action on the campus

- **Education**
- **Research, Valorisation & Funding**
- **Community**
Governance, Social Engagement,
Communication, Reporting
- **Operations**
EcoCampus, Construction & Renovation,
Energy System, Mobility, Food & Beverage,
Procurement & Waste Management,
ICT, AI & Data Management

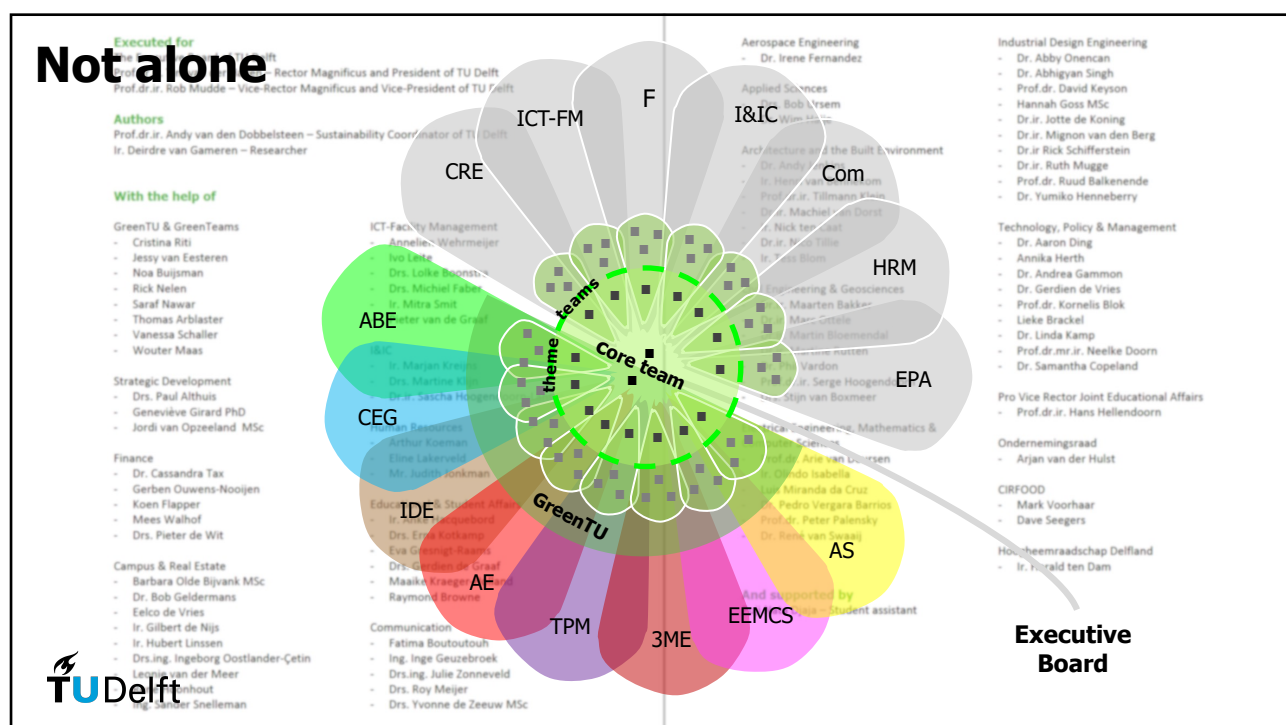


Sustainable **TU**Delft

Vision, ambition and action plan



13



14



15

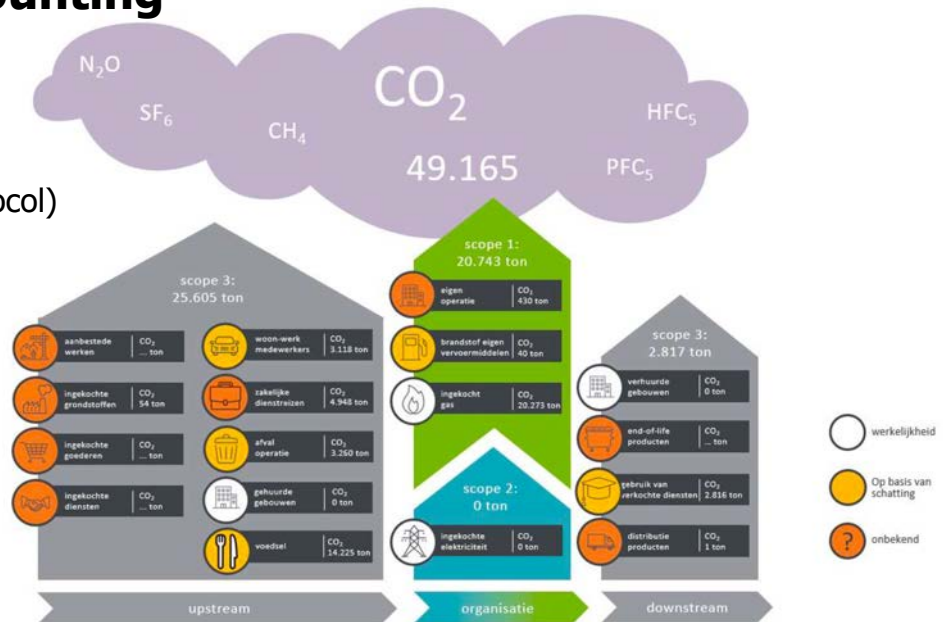


16

Carbon accounting

CO₂-eq in 2019

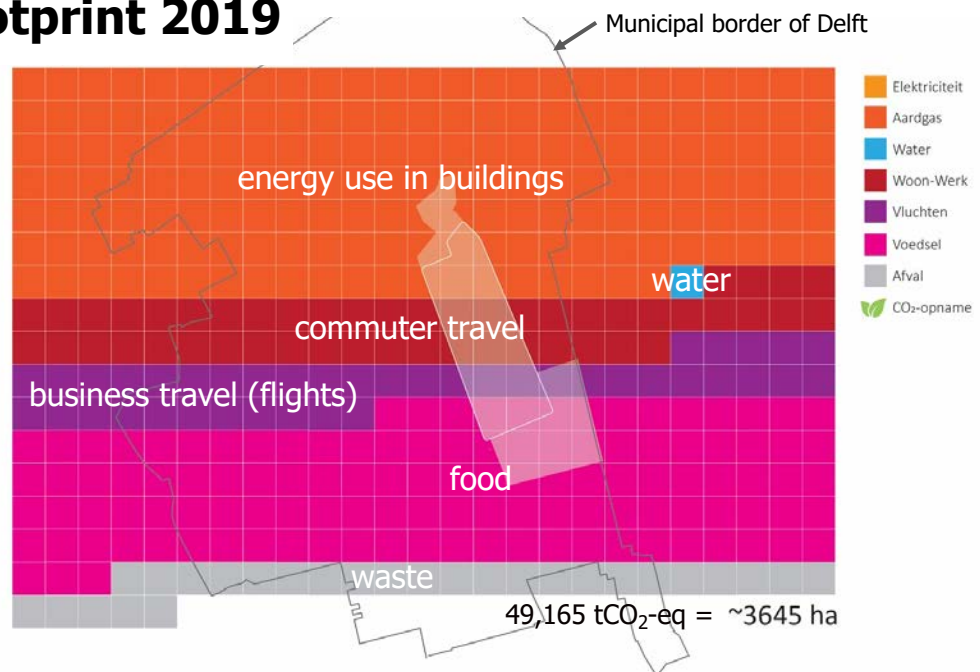
according to the
CO₂ Prestatieladder
(GHG emission protocol)



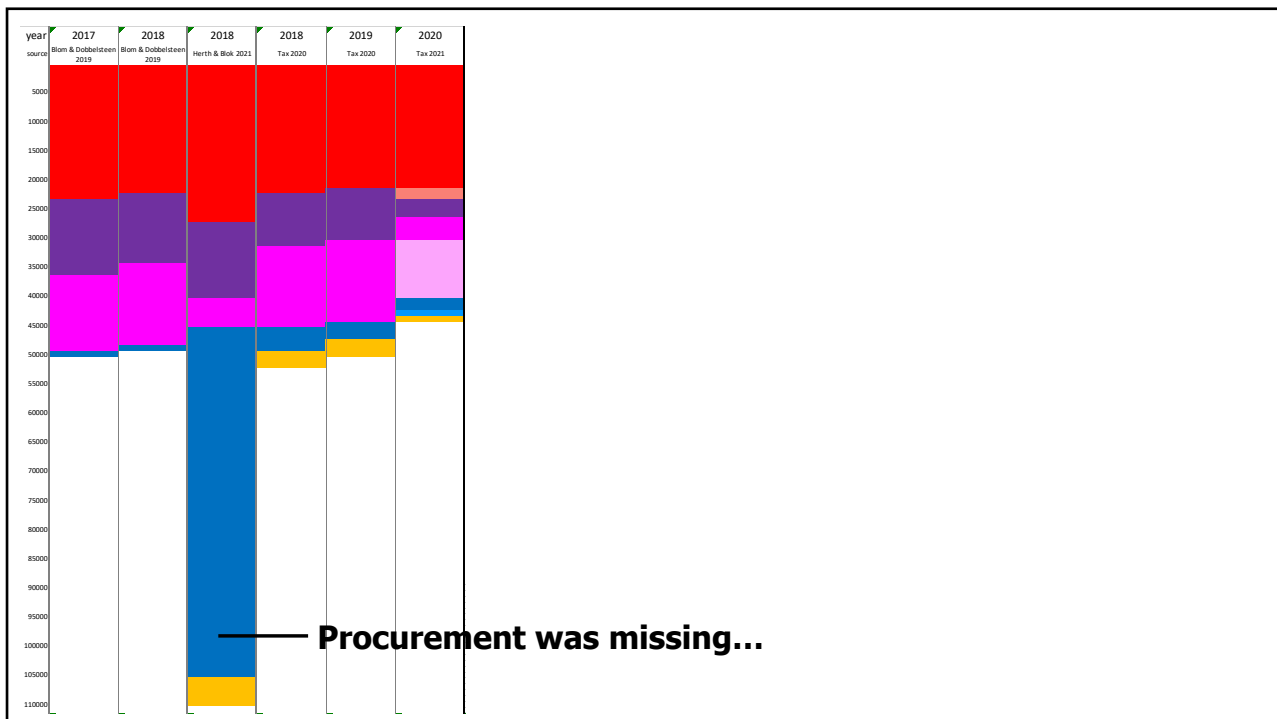
17

Carbon footprint 2019

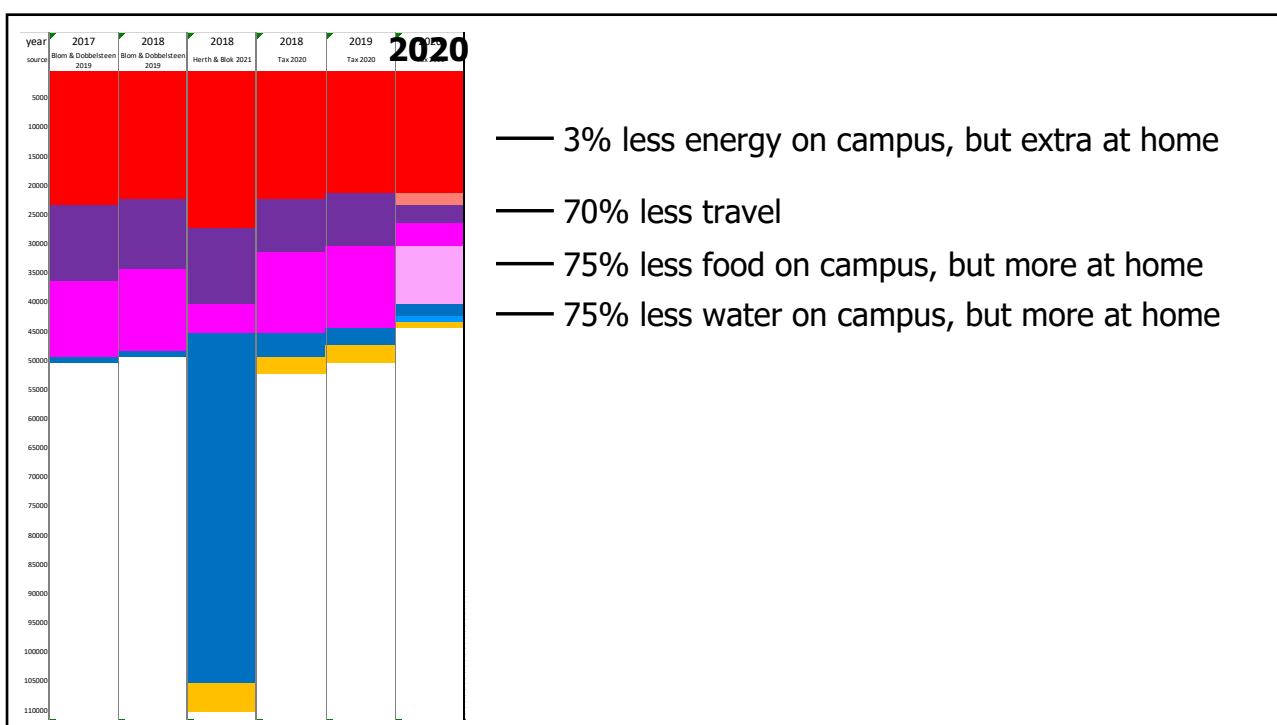
Forest area
required to
sequester
GHG emissions



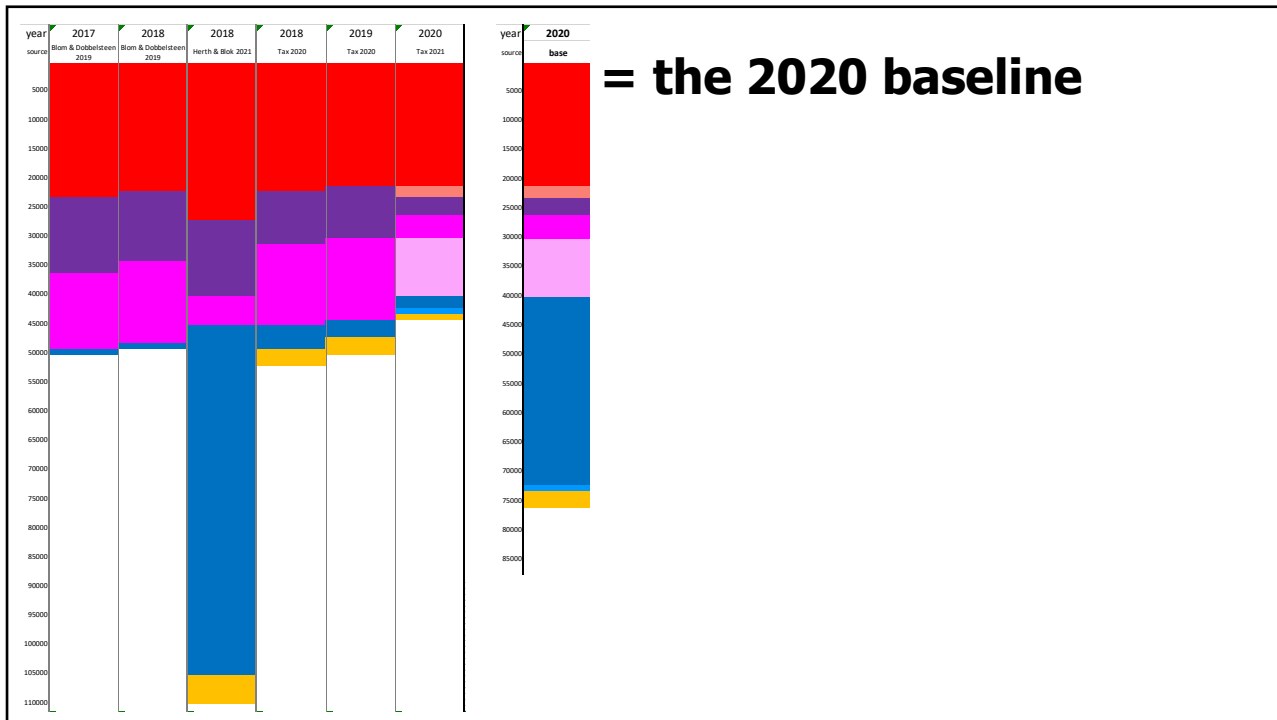
18



19



20



21

A new financial system (proposal)

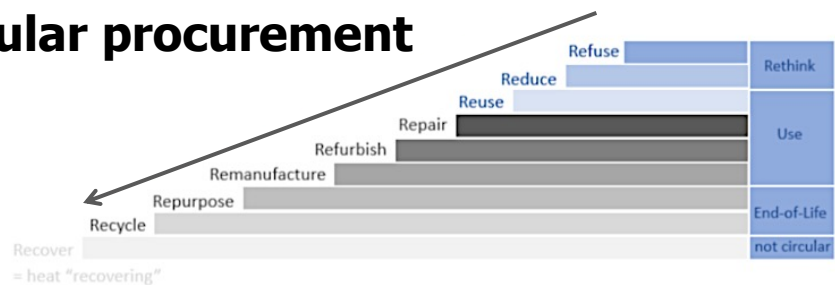
Total Cost of Ownership (TCO)
+ € 150/tonne of CO₂-eq = **TCO₂**

- For all important financial decisions
- Selection of partner bids or proposals
- Internal carbon tax (e.g. for travel)
- Internal price corrections (e.g. for food)

22

Sustainable, circular procurement

- Equipment
- Products
- Materials
- Services



→ Use the **R ladder**

→ **At all levels:** services, faculty, department, section, chair

→ **Raise awareness**

- Getting the supply chain of products sustainable

→ **Motivate or enforce** suppliers and partners

→ **Agreements with partners** we have a contract with

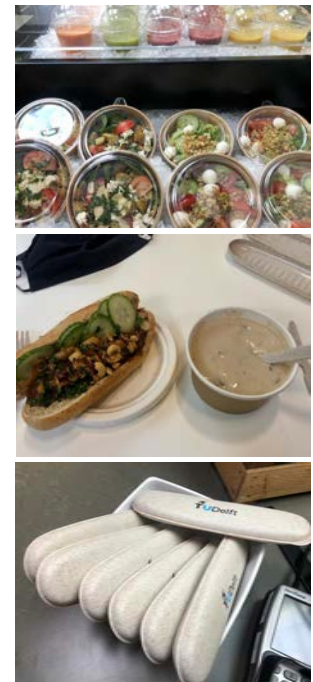
→ **Circular contracts** with new ones



23

Practical deliberations

- **Disposable or durable plates, cups and cutlery**
 - Environmental comparison of alternatives (dishwashing)
 - No disposable cups in coffee machines: buy durable ones
 - Design of (circular) portable plates, cups and cutlery
 - Stealing of TU Delft plates and mugs
- **Waste separation on site, or in a plant on the campus**
 - Clear indication of waste fractions
 - Separation and recycling/reprocessing on campus or elsewhere
 - Waste coaches



24

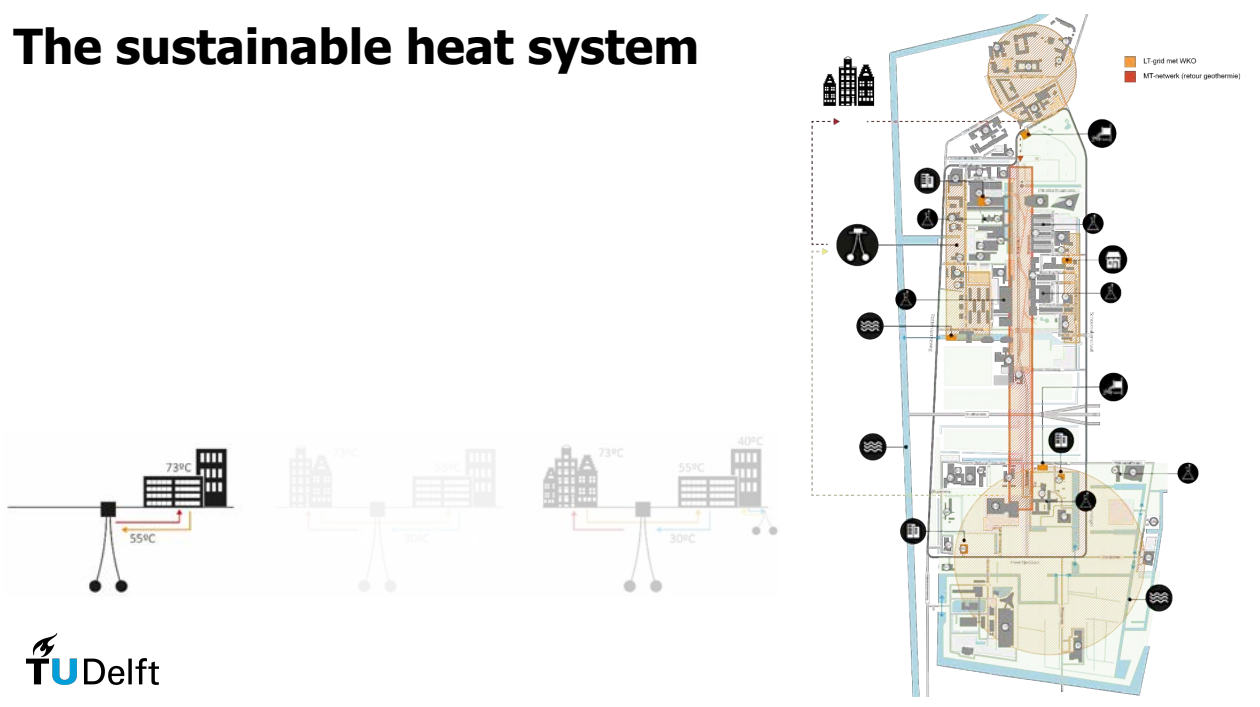
ICT, AI & data management

- **Energy efficiency for ICT & AI**
 - Effective data usage
 - Better programming
 - New (nano) computing
- **Use ICT and AI to support a smart sustainable campus**
 - Control rooms
 - Machine learning
 - Internet of things
 - Effective data usage

[www.dutchdatacenters.nl]

25

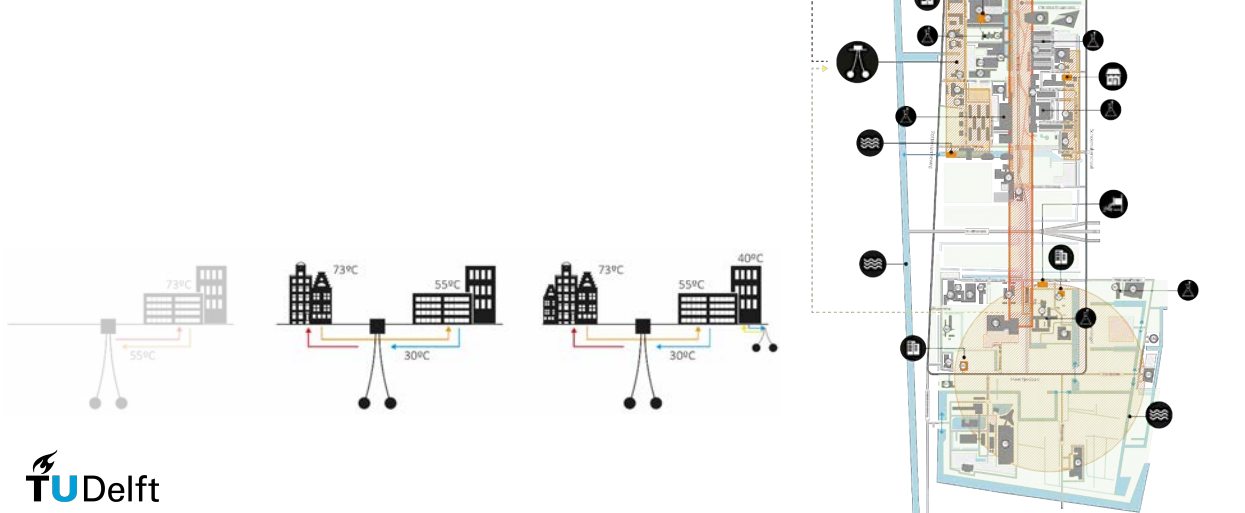
The sustainable heat system



26

The sustainable heat system

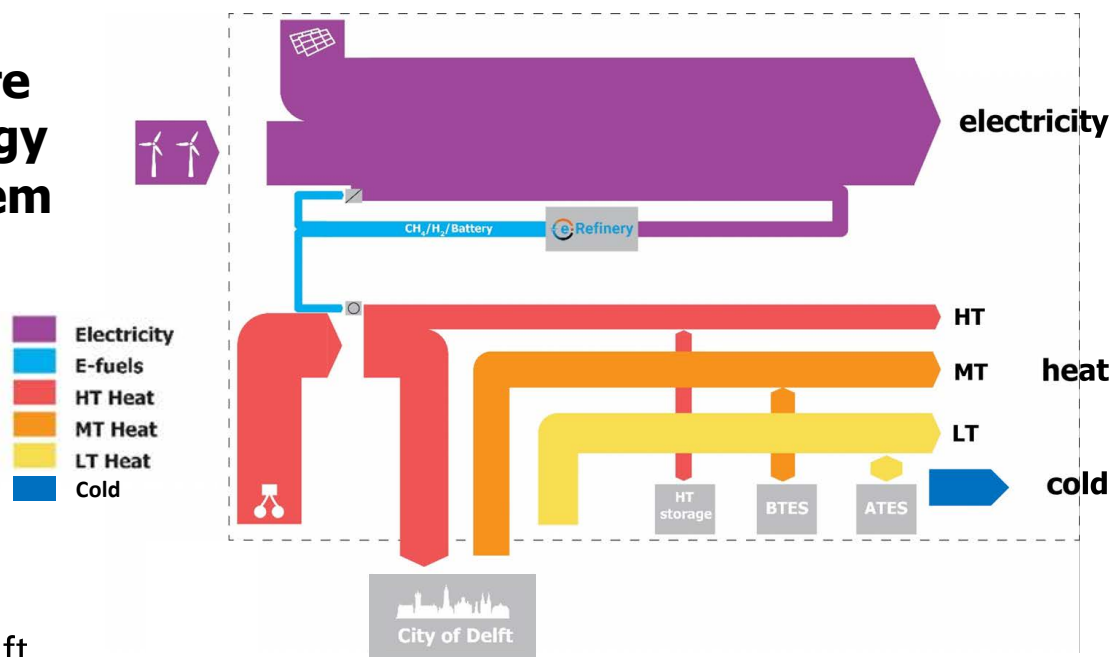
Also serving the city of Delft, in due time



TU Delft

27

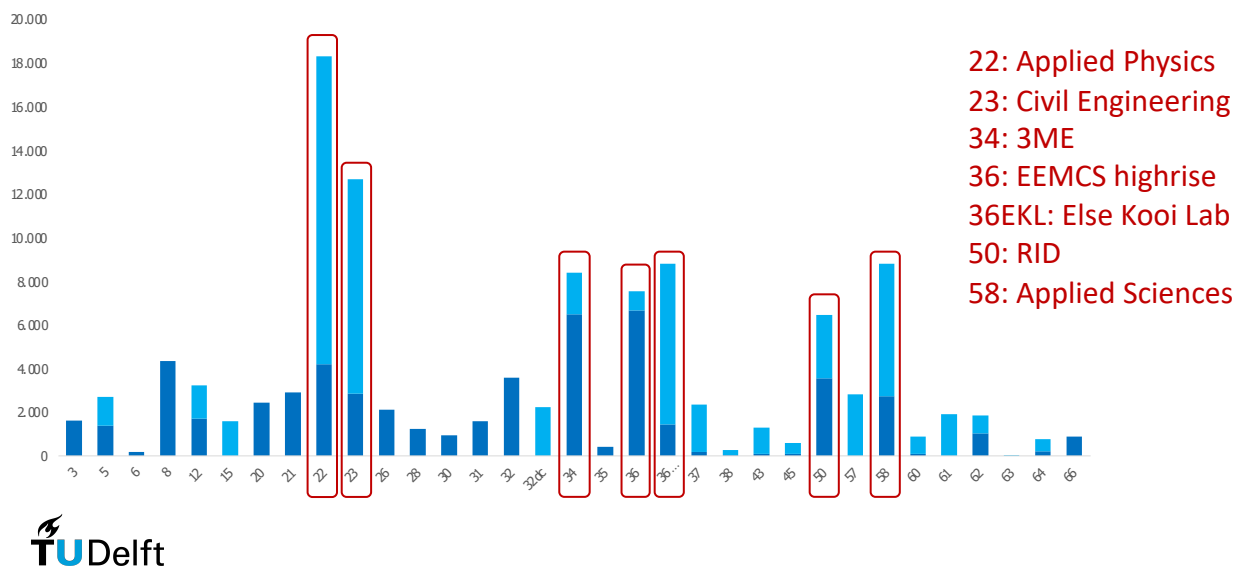
The future energy system



TU Delft

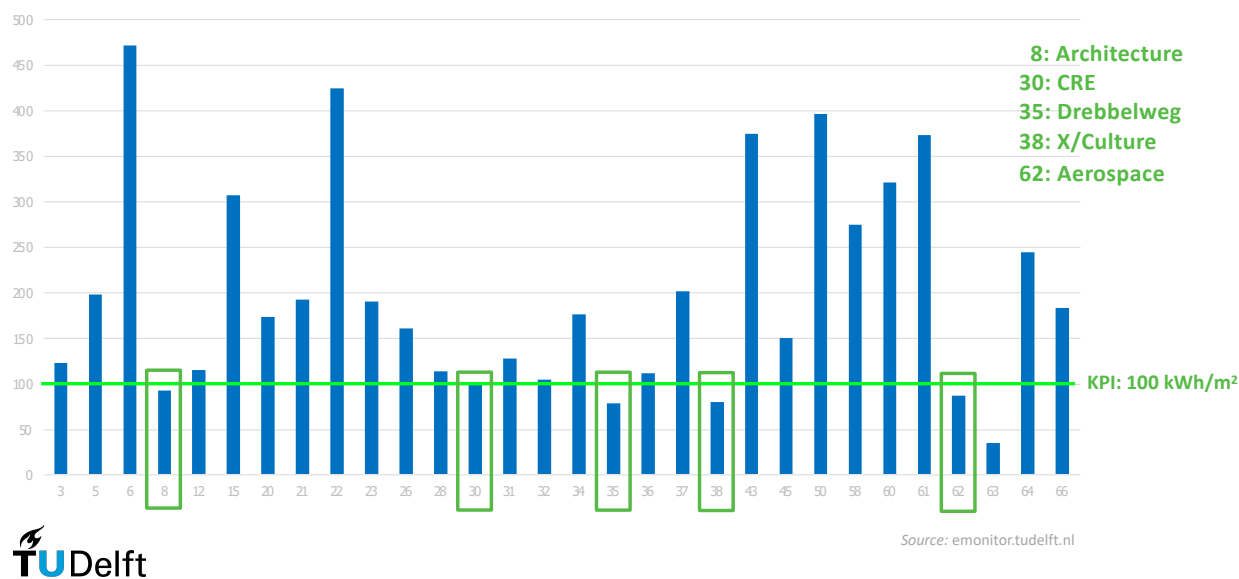
28

Absolute energy use by buildings (MWh, 2018)



29

Relative energy use by buildings (kWh/m², 2018)



30

Competition!

Weekly pop chart of faculty buildings

Ranking by kWh/m² or kWh/fte

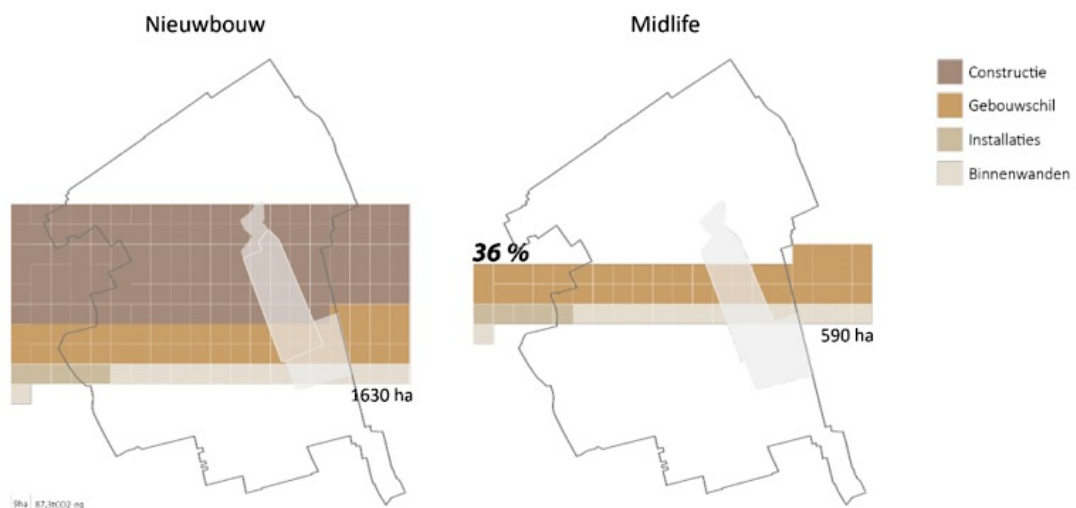


How green is your building?

This week	Last week	Weeks on chart	Building name	Building no.	Weekly carbon emission (CO ₂ e/m ²)
1	NEW	1	Pulse	33	0
2	1	10	Faculty of Aerospace Engineering	62	0.34
3	3	10	Faculty of Architecture and the Built Environment	8	0.35
4	2	9	Faculty of Industrial Design Engineering	32	0.40
5	4	8	Faculty of Electrical Engineering, Mathematics and Computer Science	36	0.43
6	5	8	Electrical Engineering, Mathematics and Computer Science	28	0.44
7	7	8	Faculty of Technology, Policy and Management	31	0.49
8	6	8	Faculty of Civil Engineering and Geosciences	26	0.62
9	8	7	Aula Conference Centre	20	0.67
10	10	7	Faculty of Mechanical, Maritime and Materials Engineering	34	0.68
11	9	7	Faculty of Civil Engineering and Geosciences	23	0.73
12	12	6	TU Delft Library	21	0.74
13	11	5	Applied Science	58	1.06
14	NEW	1	X	37 & 38	1.08
15	13	4	Physics	22	1.63

31

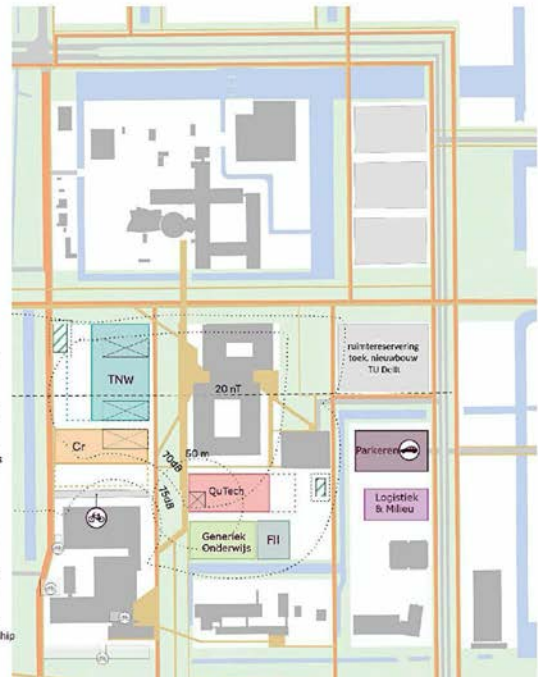
New construction versus energy renovation



32

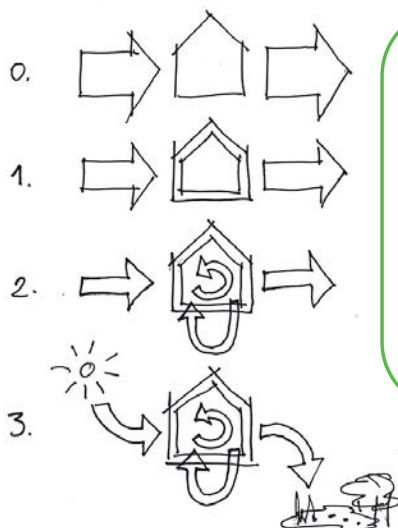
Kluyver Area: TU Delft's new sustainable flagship

- Carbon positive
- Circular
- Climate adaptive
- Contributing to liveability



33

Approach: the New Stepped Strategy



0 **research: study the local characteristics**

1 **reduce: reduce the demand**

- passive, smart bioclimatic design

2 **reuse: use residual flows**

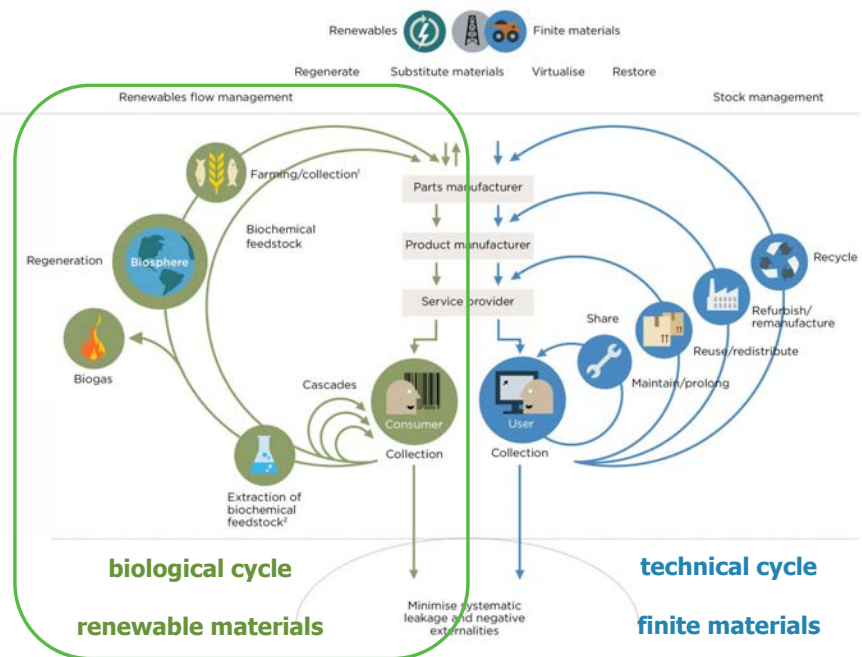
- waste water, waste material, waste heat
- in closed or connected cycles

3 **produce: generate renewable energy**

34

Circular design

- **Biobased**
 - **Modular**
 - **De- & remountable**
 - **Recycleable**
-
- **Product-service systems**
 - **Leasing products**
 - **Return systems**



35

Involve external parties on campus with our goals



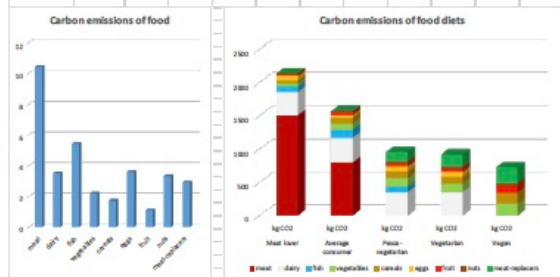
TU Delft

Firma van Buiten's new building at TU Delft Campus South

36

Environmental impact of food

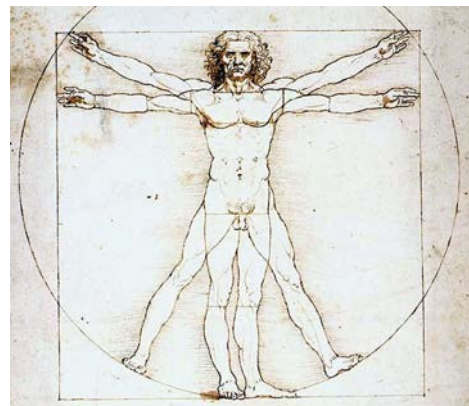
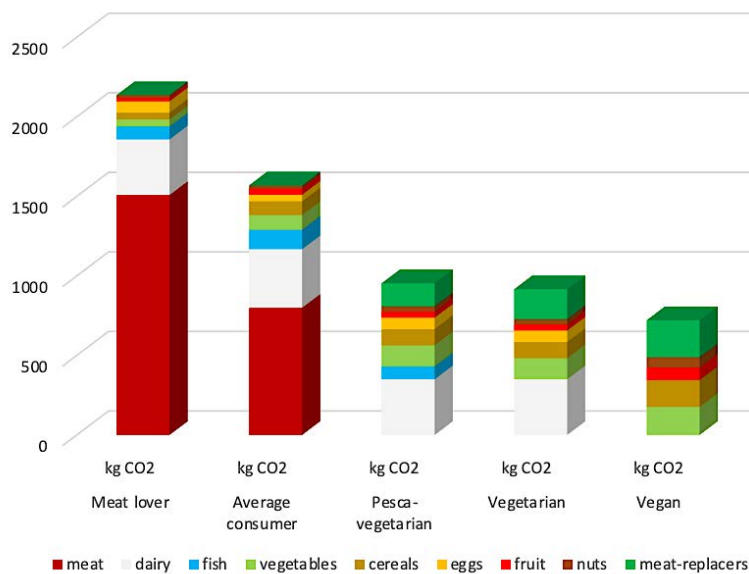
Carbon emissions of food consumption (Nt)	typical CO2e/kg		Meat lows		Average of		Pesci-veg		Vegetarian		Vegan	
	kg CO2e/kg	kg	kg CO2e/kg	kg	kg CO2e/kg	kg	kg CO2e/kg	kg	kg CO2e/kg	kg	kg CO2e/kg	kg
meat	30.4	145.0	76	361.0	76	361.0	76	361.0	76	361.0	76	361.0
dairy	3.5	100.0	105.6	100.0	100.0	0.0	350	360	350	350	0	0
fish	5.4	15.0	22.8	15.0	0.0	0.0	81	122	81	0	0	0
vegetables	2.2	20.0	42.0	60.0	60.0	60.0	44	92	132	132	178	178
fruits	1.7	20.0	50.8	60.0	60.0	60.0	43	86	102	102	132	132
eggs	3.6	20.0	11.7	20.0	20.0	0.0	72	42	72	72	0	0
nuts	1.1	20.0	35.0	35.0	35.0	70.0	22	30	30	30	77	77
fruit	3.3	5.0	5.0	5.0	10.0	10.0	27	18	33	33	66	66
meat-vegetarian	2.8	0.0	0.7	50.0	65.0	65.0	0	2	145	180	232	232
total	35.0	350.0	350.3	350.0	350.0	350.0	2136.0	1568.9	953.5	916.0	723.0	723.0



(based on
my own
research)

[illegible]

Diets matter



Brave decisions



The fully vegetarian restaurant of the faculty of Architecture & the Built Environment



Top-class vegetarian food in the Faculty Club



39

True pricing

'bonus/malus' system
based on environmental impact

Vegan is the basis
Animal products are extra
Not the other way around



Today's delicacies!



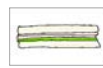
Beef burger

€ 2.95 3.14 kgCO₂eq



Vegan burger

€ 3.29 0.86 kgCO₂eq



Ham sandwich

€ 2.00 1.13 kgCO₂eq



Hummus sandwich

€ 2.00 0.5 kgCO₂eq

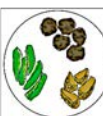


Plate set:
meatballs with
sugar snaps and
fried potatoes

€ 5.95 2.96 kgCO₂eq



Vegan plate set:
baked eggplants
with fried tofu,
lentils, and tomato

€ 5.95 1.41 kgCO₂eq



Adjusted price

€ 3.25

€ 2.95

€ 2.09

€ 1.91

€ 6.18

€ 5.72

40

Not always veg(etari)an, but clear requirements

- Healthy food
- Local food
- Seasonal food
- Organic food
- Animal-friendly food
- Less meat, fish or other animal products
- More plant-based products



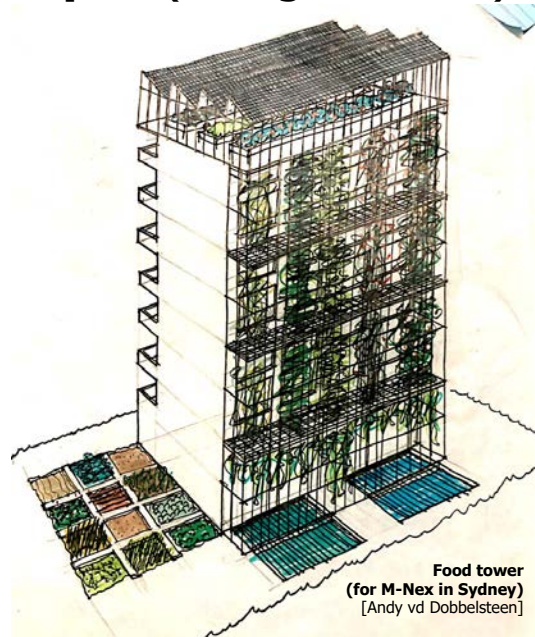
+ Own produce on the campus



41

Options for produce on the campus (fitting TU Delft)

- On (the roof of) buildings
- Attached to (the façade of) buildings
- Inside buildings
- Next to buildings
- At the Hammen Farm
 - Open-field farming
 - Horticulture
 - Aquaponics, hydroponics, aeroponics...
 - Vertical farming
 - Floating farming



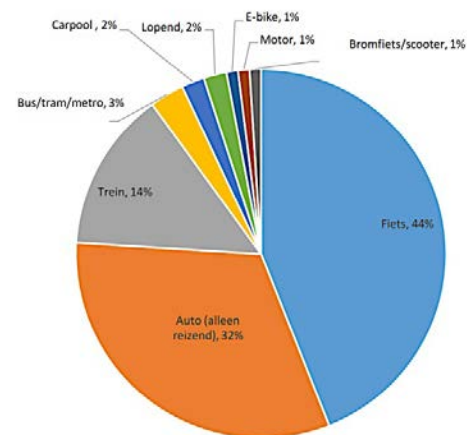
Food tower
(for M-Nex in Sydney)
[Andy vd Dobbeltstein]



42

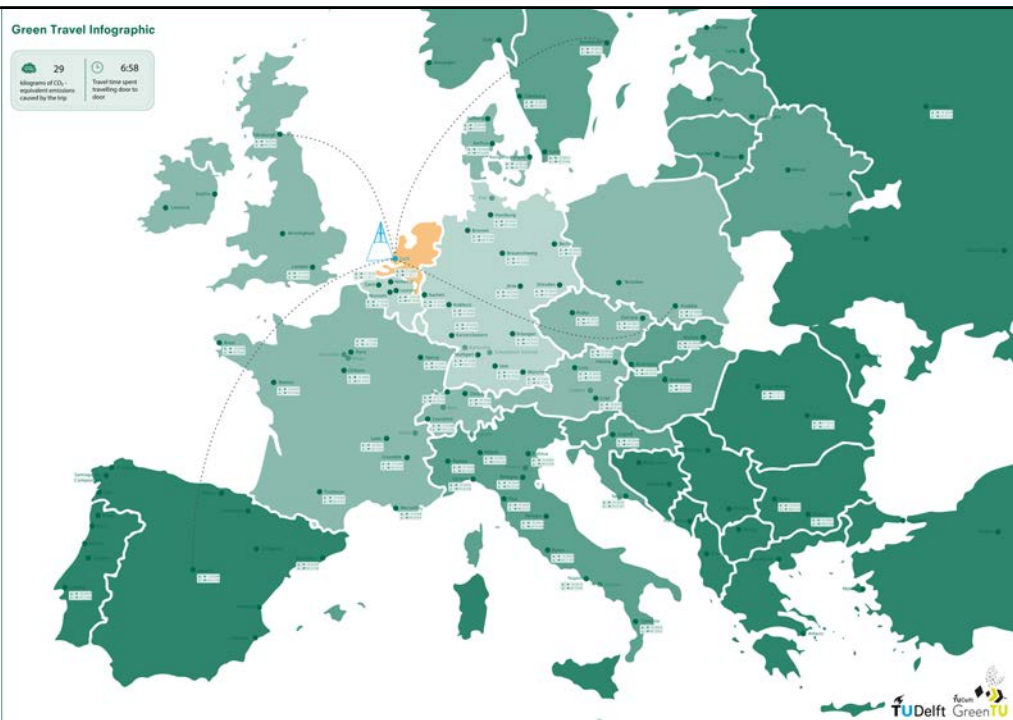
Sustainable travel to & from a fossil-free campus

- **Avoid travel**, reduce travel, plan travel smartly
- **Online and hybrid** meeting and conferences
- **Promote and stimulate (electric) bikes, public transport and electric cars**
- **Less parking space**, more green and blue
- **Trains, not planes:**
use the most sustainable mode of transport
- **Internal carbon tax** for flying,
to be used for a sustainable support fund
- **Code of conduct** and travel guidelines

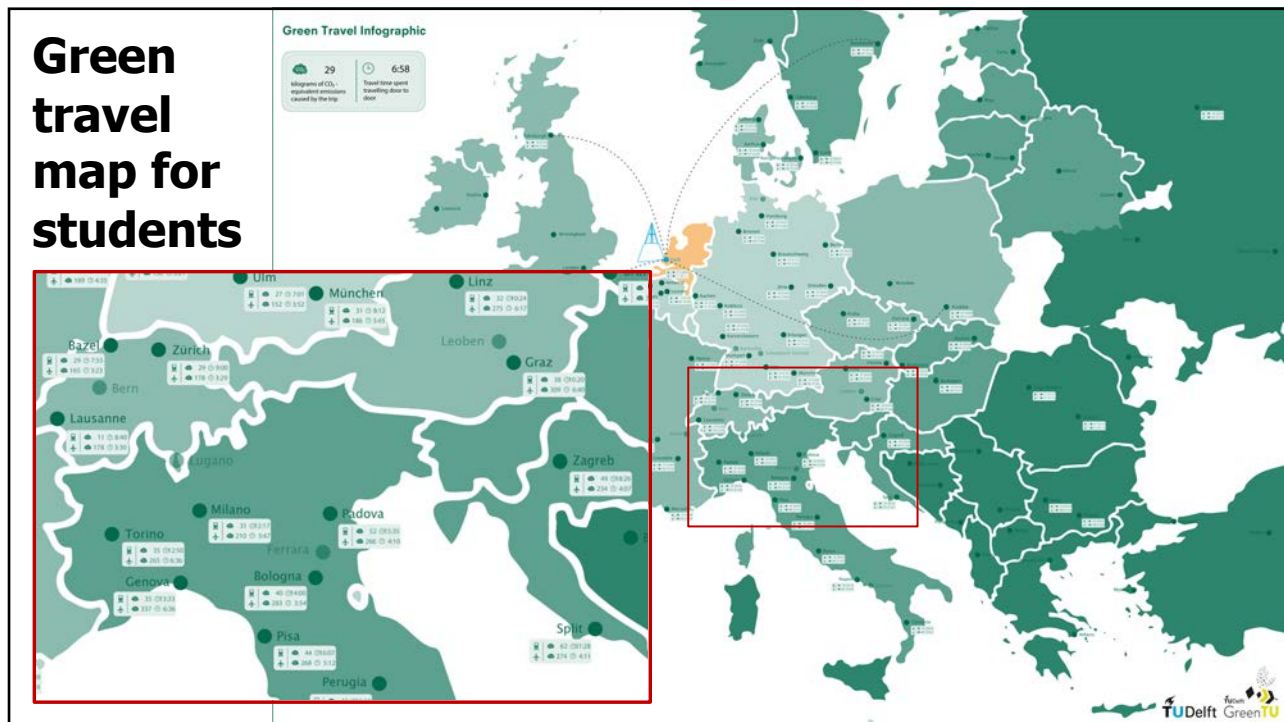


43

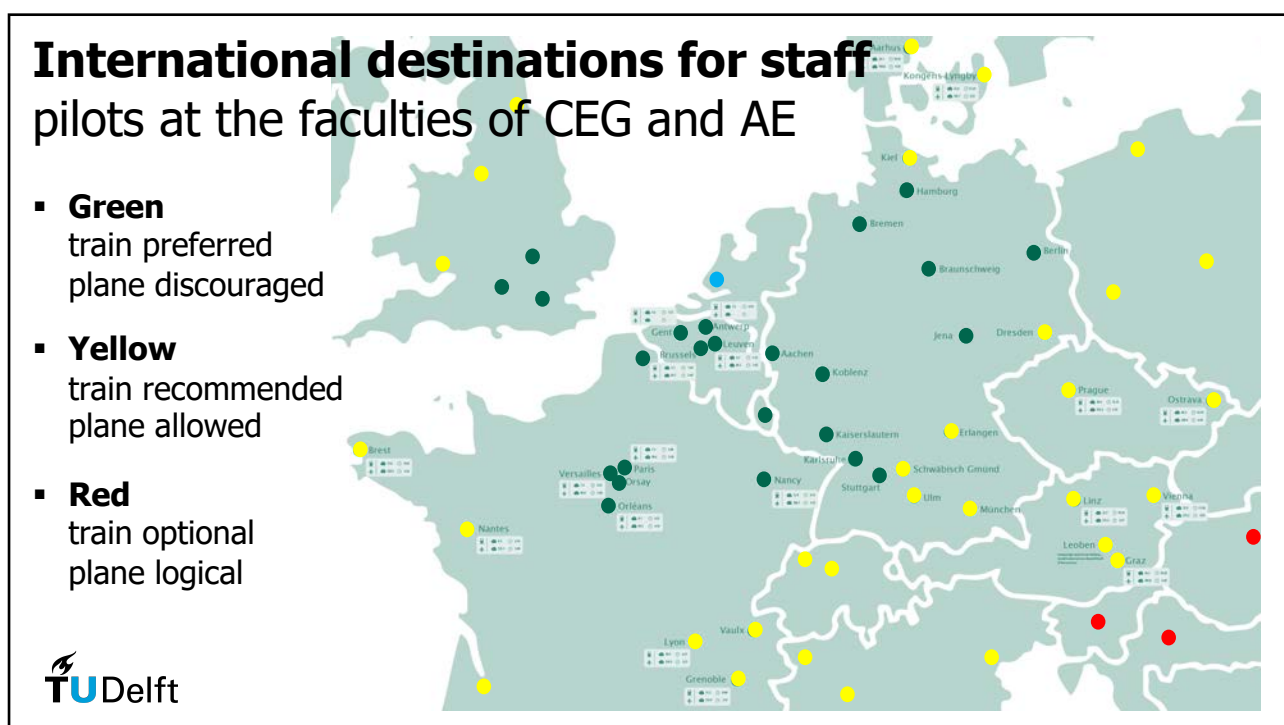
Green travel map for students



44

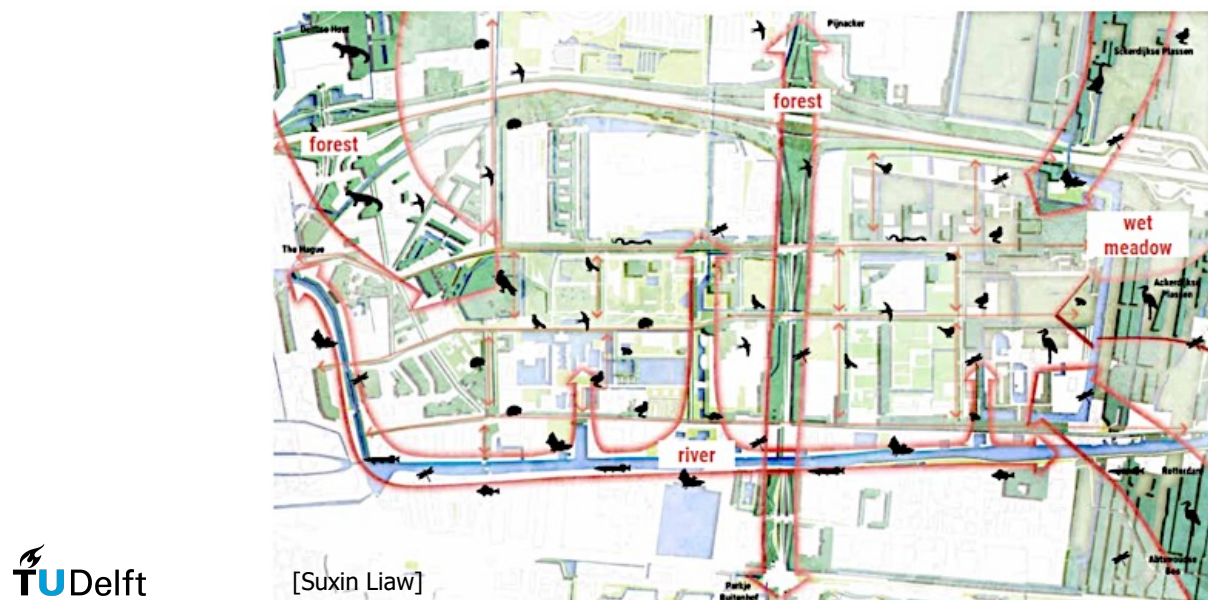


45



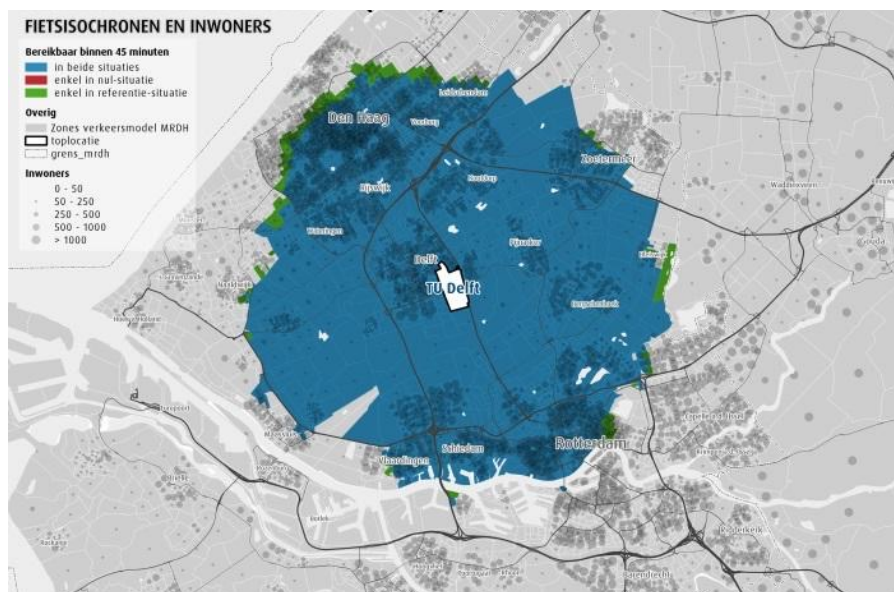
46

A greener, bluer campus

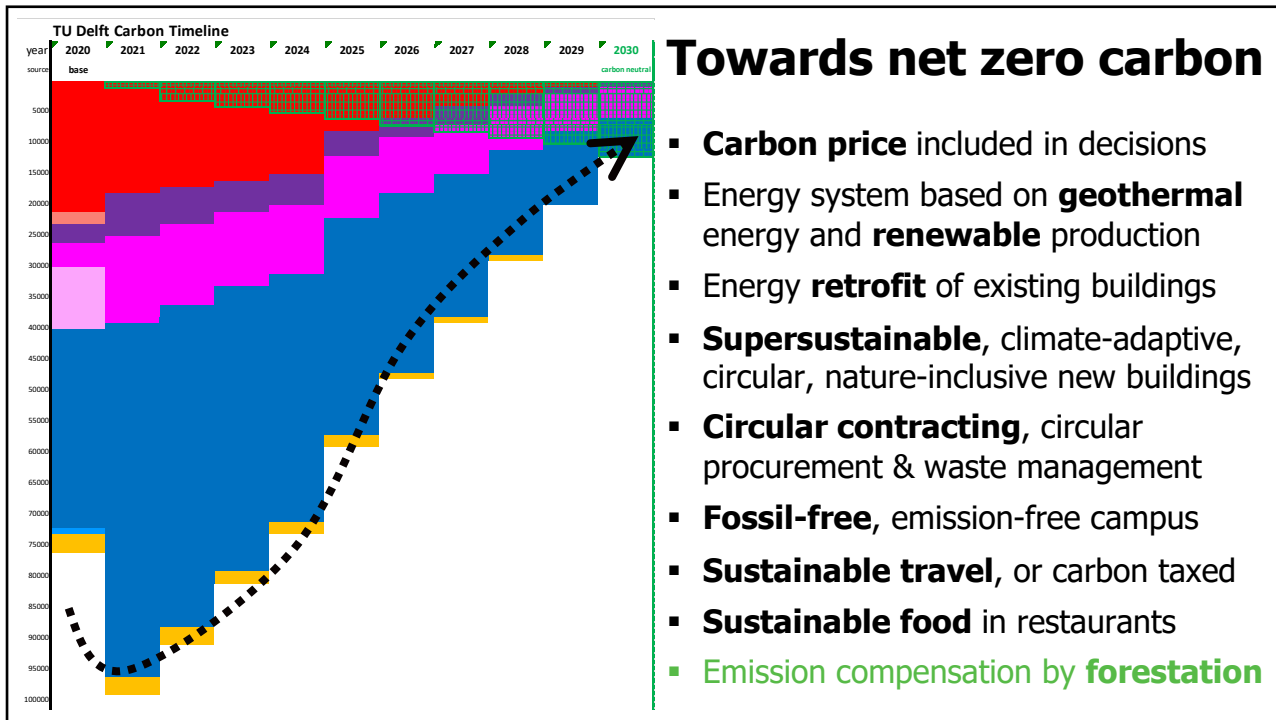


47

Connect with regional developments



48



49

Towards a just division of carbon budget – an idea

- Roughly **100.000 tonne of CO₂eq** expected for 2021
 - 28,000 students + 7,000 staff = **35,000 campus users**
- **±3 tonne of CO₂eq per campus user**

This is the **personal carbon budget**

used for accommodation, energy, procurement, food, travel...

→ To be converted to the **carbon budget of faculties and departments**

→ Personal **budget of each student**

Trading allowed!

Every year towards 2030, the carbon budget will be **reduced by 10%**

50

Onwards...

- **Discussion meetings in autumn**

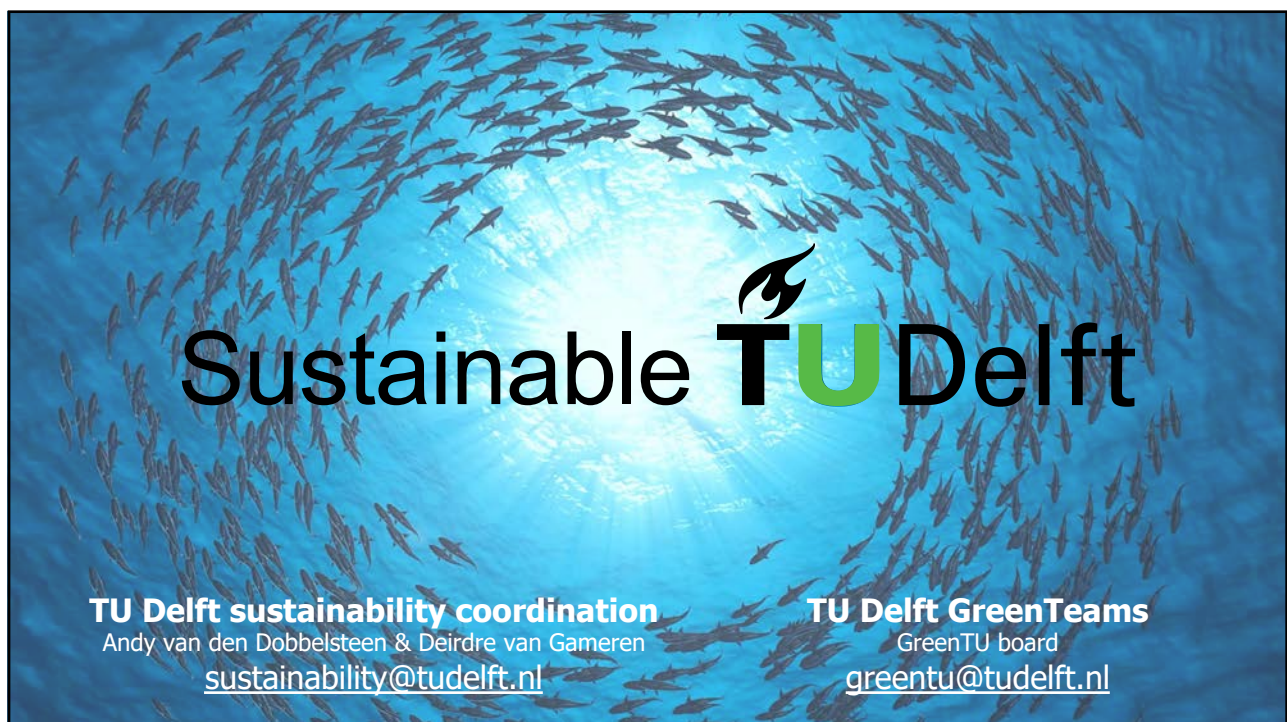
- MT or townhall meetings with all faculties and service departments
- 3 Sept: Opening Academic Year
- 6 Oct: Urban Energy Institute (3 ME)
- 13 Oct: Green TU (Library)
- 2 Nov: Prometheus (CCC @ TGV)
- 18 Nov: Delft start-ups
- Symposium with the food industry

- **New report to Executive Board by Christmas 2021**

- **TU Delft sustainability action plan starting 2022?**



51



TU Delft sustainability coordination
Andy van den Dobbelaars & Deirdre van Gameren
sustainability@tudelft.nl

TU Delft GreenTeams
GreenTU board
greenTU@tudelft.nl

52